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Title: FLAME-RETARDANT COMPOSITE COMPOSITION HAVING  
BIODEGRADABILITY AND METHOD FOR PRODUCING THE SAME

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## DESCRIPTION

Flame-retardant composite composition having  
biodegradability and method for producing the same

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## Technical Field

10 The present invention relates to a composition which is not only flame-retardant but also biodegradable when it is disposed into the natural environment, thereby enabling reduction of the adverse effect on the environment.

## Background Art

15 Recently, a variety of synthetic resin materials have been developed and provided, and the amount of the synthetic resin materials used in various fields in industry is increased year by year, and about 10,000,000 tons of various types of synthetic resins are produced annually. As a result, the 20 amount of synthetic resin waste is increased, and the method for the waste disposal poses serious social problems. Thermal disposal of the resins disposed of as such may generate toxic gas or cause a damage in the incinerator due to large heat of combustion, leading to a big load on the environment.

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Examples of conventionally known methods of disposing of resin waste include incineration or landfill of the waste resin which has been lowered in molecular weight by, e.g., heat decomposition or chemical decomposition. However, the 30 thermal disposal discharges carbon dioxide, which may cause global warming. Further, the thermal disposal of resins

containing sulfur, nitrogen, or a halogen discharges harmful gas to cause air pollution. On the other hand, in the landfill of resins, almost all the resins currently used are not decomposed for a long term and remain intact, causing soil pollution. For solving these problems, in recent years, biodegradable resins are being developed and put into practical use. The biodegradable resins biochemically decompose into carbon dioxide, water, and the like due to microorganisms or the like, and hence, after the biodegradable resins are disposed of in the natural environment, they easily decompose into low-molecular weight compounds harmless to the environment. Therefore, the use of the biodegradable resins can reduce the adverse effect of waste disposal on the environment. For this reason, the biodegradable resins have attracted attention, and have been brought into practical use in disposable products, mainly miscellaneous goods for daily use, sanitary goods, playthings, and the like.

As mentioned above, conventional biodegradable resins secure safety of the natural environment; however, the conventional biodegradable resins have only unsatisfactory flame retardancy which is increasingly demanded as one of the safety properties required for actual use of the resins. Especially in electrical appliances, it is desired that a housing or the like is formed from a biodegradable resin to facilitate the treatment of waste recovered, but the resins used in the housing for electrical appliance must meet the flame retardancy requirements prescribed in Japanese Industrial Standards (JIS) or UL (Under-writer Laboratory) standards, and the conventional biodegradable resins cannot meet the flame retardancy standard requirements.

Further, when the biodegradable resin is used in utility articles, such as housings for, e.g., electrical appliance and electronic apparatus, the resin is required to have not only the flame retardancy but also keeping properties (durability under conditions at constant temperature and humidity). For example, in small-size audio products, the resin needs to keep physical properties, such as strength, for 3 to 7 years under conditions at a relative humidity of 80% at 30°C.

Conventionally, for imparting physical properties suitable for practical shaped articles to the biodegradable resins, various studies have been made. For example, in aliphatic polyester resins which are representative examples of biodegradable polymers, with respect to the improvement of the crystallization rate by addition of inorganic filler or a nucleating agent, the blend with a biodegradable resin having elastic properties, e.g., low glass transition temperature, and the shaped article using the plastic, some patent applications have been filed (e.g., Japanese Patent Application Publications H03-290461, H04-146952, and H04-325526). However, these shaped articles are only used particularly as films and packaging materials, and hence do not have satisfactory physical properties in respect of the flame retardancy or mechanical strength.

In view of the above, an object of the present invention is to provide a composition that is biodegradable and flame-retardant and has mechanical strength, and produces less adverse impact on the natural environment when disposed.

## DISCLOSURE OF THE INVENTION

Inventors of the present invention have found that the  
5 above object is attained by adding to a biodegradable resin  
a flame retardant additive and a hydrolysis inhibitor for the  
biodegradable resin. Examples of flame retardant additives  
include halogen flame retardants, but, when the halogen flame  
retardant is added to a resin, thermal disposal of the resin  
10 containing the halogen flame retardant generates halogen gas,  
and complicated treatments are needed to make the halogen gas  
harmless to human body, and therefore the halogen flame  
retardants are not preferred examples.

15 Therefore, as flame retardant additives considering the  
environment, the present inventors have paid attention to (i)  
hydroxide compounds, (ii) ammonium phosphate compounds, and  
(iii) silica compounds. The hydroxide compounds (i) absorb  
heat generated upon burning of a resin and decompose  
20 simultaneously with generating water, so that the endothermic  
action and generation of water exhibit flame retardancy. The  
ammonium phosphate compounds (ii) decompose upon burning to  
form polymetaphosphoric acid, and a carbon film formed by the  
dehydration action shields oxygen to exhibit a flame retardancy  
25 effect. The silica compounds (iii) have an inorganic filler  
effect on a resin, thus imparting flame retardancy to the resin.  
By incorporating the flame retardant additives (i) to (iii)  
into a biodegradable resin, the resultant resin has flame  
retardancy.

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Further, the inventors of the present invention have made

studies with a view toward improving the mechanical strength of the composite resin containing the biodegradable resin and the flame retardant additives (i) to (iii). As a result, they have found that, by further adding a hydrolysis inhibitor for 5 the biodegradable resin to the composite resin, the hydrolysis rate of the biodegradable resin contained in the composite resin is retarded, so that the mechanical strength of the composite resin is maintained for a longer term.

10 Thus, the present inventors have completed a novel, ideal resin having biodegradability and flame retardancy as well as mechanical strength using a ternary system comprising a biodegradable resin, a flame retardant additive, and a hydrolysis inhibitor.

15

Specifically, the present invention is directed to:

10 (1) a composition characterized by including one or a plurality of species of organic polymer compound having biodegradability, a flame retardant additive, and a hydrolysis 20 inhibitor for the organic polymer compound having biodegradability;

25 (2) the composition according to item (1) above, characterized in that the organic polymer compound having biodegradability is a polysaccharide, an aliphatic polyester, a polyamino acid, polyvinyl alcohol, a polyalkylene glycol, or a copolymer comprising at least one of the compounds; and

30 (3) the composition according to item (1) above, characterized in that the aliphatic polyester is polylactic acid, polycaprolactone, polyhydroxybutyric acid, polyhydroxyvaleric acid, polyethylene succinate, polybutylene succinate, polybutylene adipate, polymalic acid,

a microbiologically synthesized polyester, or a copolymer comprising at least one of the compounds.

Further, the present invention is directed to:

5 (4) the composition according to item (1) above, characterized in that the flame retardant additive is at least one compound selected from a hydroxide compound, a phosphorus compound, and a silica compound;

10 (5) the composition according to item (4) above, characterized in that the flame retardant additive is a hydroxide compound having a purity of 99.5% or more;

15 (6) the composition according to item (4) above, characterized in that the flame retardant additive is a particulate hydroxide compound having a BET specific surface area of 5.0 m<sup>2</sup>/g or less;

(7) the composition according to item (4) above, characterized in that the flame retardant additive is a particulate hydroxide compound having an average particle size of 100 µm or less;

20 (8) the composition according to item (4) above, characterized in that the flame retardant additive is a silica compound having a silicon dioxide content of 50% or more; and

25 (9) the composition according to item (4) above, characterized in that the flame retardant additive is a particulate silica compound having an average particle size of 50 µm or less.

Further, the present invention is directed to:

30 (10) the composition according to item (1) above, characterized in that the hydrolysis inhibitor is at least one species of compound selected from a carbodiimide compound,

an isocyanate compound, and an oxazoline compound;

(11) a method for producing the composition according to item (1) above, characterized by mixing together one or a plurality of species of organic polymer compound having 5 biodegradability, a flame retardant additive, and a hydrolysis inhibitor for the organic polymer compound having biodegradability;

(12) a shaped article comprising the composition according to item (1) above;

10 (13) the shaped article according to item (12) above, characterized in that it is a housing for electrical appliance; and

(14) an electrical appliance comprising a part including the composition according to item (1) above as a constituent.

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#### BEST MODE FOR CARRYING OUT THE INVENTION

Hereinbelow, with respect to the composition of the present invention, the constituents and the method for 20 producing the same will be described.

With respect to the organic polymer compound having biodegradability used in the present invention (hereinafter, referred to as "biodegradable polymer compound"), there is 25 no particular limitation as long as the compound, after being used, decomposes into low-molecular weight compounds, eventually water and carbon dioxide due to microorganisms in the natural world (Biodegradable Plastics Society, ISO/TC-207/SC3). As the biodegradable polymer compound, a 30 biodegradable resin is preferred. Specific examples of biodegradable resins include polysaccharides, peptides,

aliphatic polyesters, polyamino acids, polyvinyl alcohol, polyamides, polyalkylene glycols, and copolymers comprising at least one of the above compounds, each having biodegradability.

5

Of these, as the biodegradable polymer compound used in the present invention, preferred are aliphatic polyesters excellent in mixing properties and mass-production properties. Among the aliphatic polyesters, more preferred are polylactic acids, such as poly-L-lactic acid (PLLA), and a random copolymer of L-lactic acid and D-lactic acid, and derivatives thereof. Other polyesters, e.g., polycaprolactone, polyhydroxybutyric acid, polyhydroxyvaleric acid, polyethylene succinate, polybutylene succinate, polybutylene adipate, polymalic acid, polyglycolic acid, polysuccinate, polyoxalate, polybutylene diglycolate, polydioxanone, and microbiologically synthesized polyesters can be used. Examples of the microbiologically synthesized polyesters include 3-hydroxybutyrate (3HB), 3-hydroxyvalerate (3HV), and copolymers thereof.

Examples of the polysaccharides include cellulose, starch, chitosan, dextran, and derivatives thereof and copolymers comprising one of them. Examples of the peptides include collagen, casein, fibrin, and gelatin. Examples of the polyamides include nylon 4, and a nylon 2/nylon 6 copolymer.

Further, an organic polymer compound, which is biodegradable when having a low molecular weight, and which is poor in biodegradability when having a high molecular weight, can be used in the present invention as long as the organic

polymer compound is, for example, graft-polymerized with the above-mentioned biodegradable polymer compound to exhibit biodegradability. Specific examples of such organic polymer compounds having poor biodegradability when having a high 5 molecular weight include polyethylene, polyacrylic acid derivatives, polypropylene, and polyurethane. With respect to the molecular weight and terminal group of these resins, there is no particular limitation as long as a satisfactory mechanical strength can be obtained.

10

The biodegradable polymer compound used in the present invention can be prepared by a known method. For example, the biodegradable polyester can be prepared by a method, such as (i) a lactide method, (ii) polycondensation of a polyhydric 15 alcohol and a polybasic acid, or (iii) intermolecular polycondensation of a hydroxycarboxylic acid having a hydroxyl group and a carboxyl group in its molecule.

With respect to the compound usable in the flame retardant 20 additive in the present invention, there is no particular limitation. Examples of the flame retardant additives include a variety of boric acid flame retardant compounds, phosphorus flame retardant compounds, inorganic flame retardant compounds, nitrogen flame retardant compounds, 25 halogen flame retardant compounds, organic flame retardant compounds, and colloidal flame retardant compounds. The flame retardant additives shown below may be used individually or in combination.

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Examples of boric acid flame retardant compounds include compounds containing boric acid, such as zinc borate hydrate,

barium metaborate, and borax.

Examples of phosphorus flame retardant compounds include compounds containing phosphorus, such as ammonium phosphate, 5 ammonium polyphosphate, melamine phosphate, red phosphorus, phosphoric esters, tris(chloroethyl) phosphate, tris(monochloropropyl) phosphate, tris(dichloropropyl) phosphate, triallyl phosphate, tris(3-hydroxypropyl) phosphate, tris(tribromophenyl) phosphate, 10 tris- $\beta$ -chloropropyl phosphate, tris(dibromophenyl) phosphate, tris(tribromoneopentyl) phosphate, tetrakis(2-chloroethyl) ethylenediphosphate, dimethyl methylphosphate, tris(2-chloroethyl) orthophosphate, aromatic condensed phosphates, halogen-containing condensed 15 organophosphates, ethylenebis[tris(2-cyanoethyl)]phosphonium bromide, ammonium polyphosphate,  $\beta$ -chloroethyl acid phosphate, butyl pyrophosphate, butyl acid phosphate, butoxyethyl acid phosphate, 2-ethylhexyl acid phosphate, melamine phosphate, 20 halogen-containing phosphates, and phenylphosphonic acid.

Examples of inorganic flame retardant compounds include metal sulfate compounds, such as zinc sulfate, potassium hydrosulfate, aluminum sulfate, antimony sulfate, sulfate 25 esters, potassium sulfate, cobalt sulfate, sodium hydrosulfate, iron sulfate, copper sulfate, sodium sulfate, nickel sulfate, barium sulfate, and magnesium sulfate; sulfate compounds, such as ammonium sulfate; iron oxide combustion catalysts, such as ferrocene; metal nitrate compounds, such 30 as copper nitrate; compounds containing titanium, such as titanium oxide; guanidine compounds, such as

guanidinosulfamic acid; zirconium compounds; molybdenum compounds; tin compounds; carbonate compounds, such as potassium carbonate; metal hydroxides, such as aluminum hydroxide and magnesium hydroxide; and modified compounds 5 thereof.

Examples of nitrogen flame retardant compounds include cyanurate compounds having a triazine ring.

10 Examples of halogen flame retardant compounds include flame retardant compounds containing a halogen, such as chlorinated paraffin, perchlorocyclopentadecane, hexabromobenzene, decabromodiphenyl oxide, bis(tribromophenoxy)ethane,

15 ethylenebis(dibromonorbornanedicarboximide), ethylenebis(tetrabromophthalimide), dibromoethyl(dibromocyclohexane), dibromoneopentyl glycol, 2,4,6-tribromophenol, tribromophenyl allyl ether, tetrabromobisphenol A derivatives, tetrabromobisphenol S

20 derivatives, tetracobromo(diphenoxybenzene), tris-(2,3-dibromopropyl) isocyanurate, 2,2-bis(4-hydroxy-3,5-dibromophenyl)propane, 2,2-bis(4-hydroxyethoxy-3,5-dibromophenyl)propane, poly(pentabromobenzyl acrylate), tribromostyrene,

25 tribromophenylmaleimide, tribromoneopentyl alcohol, tetrabromodipentaerythritol, pentabromobenzyl acrylate, pentabromophenol, pentabromotoluene, pentabromodiphenyl oxide, hexabromocyclododecane, hexabromodiphenyl ether, octabromophenol ether, octadibromodiphenyl ether,

30 octabromodiphenyl oxide, magnesium hydroxide, dibromoneopentyl glycol tetracarbonate,

bis(tribromophenyl)fumaramide,  
N-methylhexabromodiphenylamine, bromostyrene, and diallyl  
chlorendate.

5 Examples of organic flame retardant compounds include  
chlorendic anhydride; phthalic anhydride; compounds  
containing bisphenol A; glycidyl compounds, such as glycidyl  
ether; polyhydric alcohols, such as diethylene glycol and  
pentaerythritol; modified carbamide; silicone oil; and silica  
10 compounds, such as silicon dioxide, low-melting point glass,  
and organosiloxane.

Examples of the colloidal flame retardant compounds  
include colloids of conventionally used hydroxides having  
15 flame retardancy, such as aluminum hydroxide, magnesium  
hydroxide, and calcium hydroxide; hydrates, such as calcium  
aluminate, gypsum dihydrate, zinc borate, barium metaborate,  
borax, and kaolin clay; nitrate compounds, such as sodium  
nitrate; and flame retardant compounds, such as molybdenum  
20 compounds, zirconium compounds, antimony compounds,  
dawsonite, and plogopite.

With respect to the flame retardant additive in the present  
invention, especially preferred are ones that do not cause  
25 a load on the environment after the disposal, for example,  
generate no toxic gas during the thermal disposal. From the  
viewpoint of the environmental consideration, as the flame  
retardant additive in the present invention, it is desired  
that (i) a hydroxide compound, such as aluminum hydroxide,  
30 magnesium hydroxide, or calcium hydroxide; (ii) the  
above-mentioned phosphorus compound, especially an ammonium

phosphate compound, such as ammonium phosphate or ammonium polyphosphate; or (iii) a silica compound, such as silicon dioxide, low-melting point glass, or organosiloxane is used.

5        In the silica compounds preferred as the flame retardant additive used in the present invention, more preferred are silica compounds having a silicon dioxide content of about 50% or more. The reason for this is that the silica compound taken out from natural minerals inevitably contains a certain  
10 amount of substances other than the silica compound (e.g., MgO, CaO, Fe<sub>2</sub>O<sub>3</sub>, and Al<sub>2</sub>O<sub>3</sub>). It is preferred that the flame retardant effect of the inorganic filler is not lowered by the impurities.

15        In the hydroxide compounds preferred as the flame retardant additive used in the present invention, more preferred are ones having a purity of about 99.5% or more. The reason for this is that the shelf stability is improved when using the hydroxide compound having a higher purity and  
20 the hydrolysis inhibitor in combination. The hydroxide compound purity can be measured by a known method. For example, the amount of impurities contained in the hydroxide compound is measured by a known method, and the amount of impurities is subtracted from the amount of the hydroxide compound to  
25 determine a purity of the hydroxide compound. More specifically, as examples of impurities contained in, for example, aluminum hydroxide, there can be mentioned Fe<sub>2</sub>O<sub>3</sub>, SiO<sub>2</sub>, T-Na<sub>2</sub>O, and S-Na<sub>2</sub>O. The Fe<sub>2</sub>O<sub>3</sub> amount is determined by melting aluminum hydroxide in a boric acid solution of sodium  
30 carbonate and subjecting it to O-phenanthroline absorption spectrophotometry (JIS H 1901). The SiO<sub>2</sub> amount is determined

by melting aluminum hydroxide in a boric acid solution of sodium carbonate and subjecting it to molybdenum blue absorption spectrophotometry (JIS H 1901). The T-Na<sub>2</sub>O amount is determined by melting aluminum hydroxide in sulfuric acid and 5 subjecting it to flame spectrometry, and the S-Na<sub>2</sub>O amount is determined by extracting aluminum hydroxide with warm water and subjecting the extract to flame spectrometry. The above-determined amount value is subtracted from the weight of the aluminum hydroxide to obtain a purity of the aluminum 10 hydroxide. A plurality of different flame retardant hydroxide compounds each having a purity of 99.5% or more can be used in combination.

With respect to the form of the flame retardant additive 15 used in the present invention, there is no particular limitation, but it is preferred that the flame retardant additive is particulate. The particle size of the flame retardant additive can be appropriately selected depending on the type of the flame retardant additive used. For example, 20 when the flame retardant additive is a silica compound, such as SiO<sub>2</sub> or glass, it is preferred that it has an average particle size of about 50  $\mu\text{m}$  or less, as measured by a laser diffraction method. In this case, the particle size distribution is not limited. On the other hand, when the flame retardant additive 25 is a hydroxide compound, such as Al(OH)<sub>3</sub>, Mg(OH)<sub>2</sub>, or Ca(OH)<sub>2</sub>, it is preferred that it has an average particle size of about 100  $\mu\text{m}$  or less, as measured by a laser diffraction method. In this case, the particle size distribution is not limited. From the viewpoint of achieving excellent injection 30 moldability in the molding process and excellent dispersion properties in the kneading, the average particle size of the

flame retardant additive is preferably in the above range, more preferably smaller in the range. For increasing the filling density of the flame retardant additive in the composition, a plurality of flame retardant additives having 5 different average particle sizes can be used in combination.

Further, when the flame retardant additive is a hydroxide compound, such as  $\text{Al(OH)}_3$ ,  $\text{Mg(OH)}_2$ , or  $\text{Ca(OH)}_2$ , it is preferred to use particles having a BET specific surface area of about 10  $5.0 \text{ m}^2/\text{g}$  or less, as measured by a nitrogen gas absorption method. For increasing the filling density of the flame retardant additive in the composition, a plurality of flame retardant hydroxide compounds having different BET specific surface areas can be used in combination. From the viewpoint 15 of achieving excellent moldability, the BET specific surface area of the flame retardant additive is preferably in the above range, more preferably smaller in the range.

The amount of the flame retardant additive added in the 20 present invention can be arbitrarily determined as long as satisfactory mechanical strength of the composition of the present invention can be secured. With respect to the specific amount of the flame retardant additive added, when the flame retardant additive is a hydroxide compound, such as  $\text{Al(OH)}_3$ , 25  $\text{Mg(OH)}_2$ , or  $\text{Ca(OH)}_2$ , the amount may be about 5 to 50% by weight, preferably about 7.5 to 45% by weight, further preferably about 10 to 40% by weight. When the flame retardant additive is 30 an ammonium (poly)phosphate compound, such as  $(\text{NH}_4)_3(\text{P}_n\text{O}_{3n+1})^{(n+2)}$  (wherein n is a natural number), the amount may be about 1 to 25% by weight, preferably about 2 to 20% by weight, further preferably about 3 to 15% by weight. When

the flame retardant additive is a silica compound, such as SiO<sub>2</sub> or glass, the amount may be about 5 to 40% by weight, preferably about 10 to 35% by weight, further preferably about 15 to 30% by weight.

5

With respect to the hydrolysis inhibitor used in the present invention, there is no particular limitation as long as it is an additive which inhibits the biodegradable polymer compound from hydrolyzing. Examples of the hydrolysis 10 inhibitors include compounds having reactivity with active hydrogen in the biodegradable polymer compound. By adding such a compound, the amount of active hydrogen in the biodegradable polymer compound is reduced, making it possible to suppress hydrolysis of the biodegradable polymer chain due 15 to the catalytic action of active hydrogen. Here, the active hydrogen means hydrogen bonded to oxygen or nitrogen (hydrogen in an N-H bond or O-H bond), and hydrogen of this type has high reactivity, as compared to hydrogen bonded to carbon (hydrogen in a C-H bond). More specifically, examples include 20 hydrogen in a carboxyl group: -COOH; a hydroxyl group: -OH; an amino group: -NH<sub>2</sub>; or an amide linkage: -NHCO- in the biodegradable polymer compound.

As the compound having reactivity with active hydrogen 25 in the biodegradable polymer compound, a carbodiimide compound, an isocyanate compound, and an oxazoline compound can be used. Especially preferred is a carbodiimide compound which can be melt-kneaded together with the biodegradable polymer compound, and can more remarkably suppress the hydrolysis even when used 30 in a small amount.

The carbodiimide compound is a compound having in its molecule one or more carbodiimide groups, and includes polycarbodiimide compounds. As a method for preparing the carbodiimide compound, there can be mentioned a method in which,

5 using as a catalyst, an organophosphorus compound, such as O,O-dimethyl-O-(3-methyl-4-nitrophenyl) phosphorothioate, O,O-dimethyl-O-[3-methyl-4-(methylthio)phenyl] phosphorothioate, or

10 O,O-diethyl-O-2-isopropyl-6-methylpyridine-4-yl phosphorothioate, or an organometal compound, such as a rhodium complex, a titanium complex, a tungsten complex, or a palladium complex, a certain polymer isocyanate is subjected to decarboxylative polycondensation at about 70°C or higher in the absence of a solvent or in an inert solvent (e.g., hexane,

15 benzene, dioxane, or chloroform) to prepare a carbodiimide compound.

Examples of monocarbodiimide compounds included in the carbodiimide compounds include dicyclohexylcarbodiimide, diisopropylcarbodiimide, dimethylcarbodiimide, diisobutylcarbodiimide, dioctylcarbodiimide, diphenylcarbodiimide, and naphthylcarbodiimide, and, of these, preferred are dicyclohexylcarbodiimide and diisopropylcarbodiimide, which are especially easily available commercially.

Examples of isocyanate compounds, which are compounds having reactivity with active hydrogen in the biodegradable polymer compound, include 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, m-phenylene diisocyanate, p-phenylene diisocyanate, 4,4'-diphenylmethane diisocyanate,

2,4'-diphenylmethane diisocyanate, 2,2'-diphenylmethane diisocyanate, 3,3'-dimethyl-4,4'-biphenylene diisocyanate, 3,3'-dimethoxy-4,4'-biphenylene diisocyanate, 3,3'-dichloro-4,4'-biphenylene diisocyanate,

5 1,5-naphthalene diisocyanate, 1,5-tetrahydronaphthalene diisocyanate, tetramethylene diisocyanate, 1,6-hexamethylene diisocyanate, trimethylhexamethylene diisocyanate, 1,3-cyclohexylene diisocyanate, 1,4-cyclohexylene

10 diisocyanate, xylylene diisocyanate, tetramethylxylylene diisocyanate, hydrogenated xylylene diisocyanate, lysine diisocyanate, isophorone diisocyanate, 4,4'-dicyclohexylmethane diisocyanate, and 3,3'-dimethyl-4,4'-dicyclohexylmethane diisocyanate.

15

The isocyanate compound can be easily prepared by a known method, and a commercially available isocyanate compound can be appropriately selected. As a commercially available polyisocyanate compound, an aromatic isocyanate adduct, such

20 as Coronate (manufactured and sold by NIPPON POLYURETHANE INDUSTRY CO., LTD.; hydrogenated diphenylmethane diisocyanate) or Millionate (manufactured and sold by NIPPON POLYURETHANE INDUSTRY CO., LTD.), can be used. Of these, it is preferred to use, for example, a polyisocyanate compound

25 having an isocyanate group blocked with a masking agent (e.g., a polyhydric aliphatic alcohol or aromatic polyol), which is in a state of solid rather than liquid, when the composition of the present invention is produced by melt-kneading.

30 Examples of oxazoline compounds, which are compounds having reactivity with active hydrogen in the biodegradable

polymer compound, include 2,2'-o-phenylenebis(2-oxazoline),  
2,2'-m-phenylenebis(2-oxazoline),  
2,2'-p-phenylenebis(2-oxazoline),  
2,2'-p-phenylenebis(4-methyl-2-oxazoline),  
5 2,2'-m-phenylenebis(4-methyl-2-oxazoline),  
2,2'-p-phenylenebis(4,4'-dimethyl-2-oxazoline),  
2,2'-m-phenylenebis(4,4'-dimethyl-2-oxazoline),  
2,2'-ethylenebis(2-oxazoline),  
2,2'-tetramethylenebis(2-oxazoline),  
10 2,2'-hexamethylenebis(2-oxazoline),  
2,2'-octamethylenebis(2-oxazoline),  
2,2'-ethylenebis(4-methyl-2-oxazoline), and  
2,2'-diphenylenebis(2-oxazoline).

15 The biodegradation rate and the mechanical strength of the composition of the present invention can be controlled by changing the type and amount of the hydrolysis inhibitor used in the present invention, and therefore the type and amount of the hydrolysis inhibitor incorporated may be determined  
20 depending on the desired product. Specifically, it is preferred that the amount of the hydrolysis inhibitor added is about 5% by weight or less. As the hydrolysis inhibitor, the above compounds may be used individually or in combination.

25 With respect to the method for producing the composition of the present invention, there is no particular limitation, and a known method may be used. As a preferred example of the method for producing the composition, there can be mentioned a method in which the above-mentioned flame retardant  
30 additive and hydrolysis inhibitor are melt-kneaded with the organic polymer compound having biodegradability to prepare

a composition. In the method by melt-kneading, the flame retardant additive and the hydrolysis inhibitor are added and mixed with each other before or while melting the organic polymer compound having biodegradability. In this case, the 5 flame retardant additive and the hydrolysis inhibitor may be added either at the same time or successively. When they are successively added, any of them may be first added. In addition, there can be mentioned a method in which the organic polymer compound having biodegradability is melted and then, any one 10 of the flame retardant additive and the hydrolysis inhibitor is added and mixed, and the resultant composition is melted again and the remaining hydrolysis inhibitor or flame retardant additive is added thereto and mixed with one another.

15 The composition of the present invention may contain another known additive in an amount such that the desired effects of the composition of the present invention are not sacrificed. Examples of the known additives include reinforcement, inorganic or organic filler, an antioxidant, 20 a heat stabilizer, an ultraviolet light absorber, a lubricant, a wax, a coloring agent, a crystallization promoter, and an organic substance having degradability, such as starch. These may be used individually or in combination.

25 Examples of the reinforcement include glass microbead, carbon fiber, chalk, quartz, such as novoculite, silicates, such as asbestos, feldspar, mica, talc, and wollastonite, and kaolin. Examples of inorganic filler include carbon, silicon dioxide, metal oxide fine particles, such as alumina, silica, 30 magnesia, and ferrite, silicates, such as talc, mica, kaolin, and zeolite, and fine particles of barium sulfate, calcium

carbonate, or fullerene, and examples of organic filler include epoxy resins, melamine resins, urea resins, acrylic resins, phenolic resins, polyimide resins, polyamide resins, polyester resins, and Teflon (registered trademark) resins.

5 Of these, preferred are carbon and silicon dioxide. The above filler may be used individually or in combination.

Examples of the antioxidants include phenolic, amine, phosphorus, sulfur, hydroquinone, and quinoline antioxidants.

10 Examples of phenolic antioxidants include hindered phenols, for example, C<sub>2-10</sub> alkylenediol-bis[3-(3,5-di-branched C<sub>3-6</sub> alkyl-4-hydroxyphenyl) propionate], such as 2,6-di-t-butyl-p-cresol,

1,3,5-trimethyl-2,4,6-tris(3,5-di-t-butyl-4-hydroxybenzyl

15 )benzene, 2,2'-methylenebis(4-methyl-6-t-butylphenol), 4,4'-methylenebis(2,6-di-t-butylphenol), 4,4'-butylidenebis(3-methyl-6-t-butylphenol), and 1,6-hexanediol

bis[3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate]; di- or

20 trioxy C<sub>2-4</sub> alkylenediol bis[3-(3,5-di-branched C<sub>3-6</sub> alkyl-4-hydroxyphenyl)propionate], such as triethylene glycol

bis[3-(3-t-butyl-5-methyl-4-hydroxyphenyl)propionate];

C<sub>3-8</sub> alkanetriol bis[3-(3,5-di-branched C<sub>3-6</sub>

25 alkyl-4-hydroxyphenyl)propionate], such as glycerol tris[3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate]; C<sub>4-8</sub> alkanetetraol tetrakis[3-(3,5-di-branched C<sub>3-6</sub> alkyl-4-hydroxyphenyl)propionate], such as pentaerythritol tetrakis[3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate];

30 and n-octadecyl 3-(4',5'-di-t-butylphenol)propionate, n-octadecyl

3-(4'-hydroxy-3',5'-di-t-butylphenol)propionate, stearyl  
 2-(3,5-di-t-butyl-4-hydroxyphenol)propionate, distearyl  
 3,5-di-t-butyl-4-hydroxybenzylphosphonate,  
 2-t-butyl-6-(3-t-butyl-5-methyl-2-hydroxybenzyl)-4-methyl  
 5 phenyl acrylate,  
 N,N'-hexamethylenebis(3,5-di-t-butyl-4-hydroxy-hydrocinna  
 mamide),  
 3,9-bis{2-[3-(3-t-butyl-4-hydroxy-5-methylphenyl)propiony  
 loxy]-1,1-dimethylethyl}-2,4,8,10-tetraoxaspiro[5,5]undec  
 10 ane, 4,4'-thiobis(3-methyl-6-t-butylphenol), and  
 1,1,3-tris(2-methyl-4-hydroxy-5-t-butylphenol)butane.

Examples of amine antioxidants include phenyl-1-naphthylamine, phenyl-2-naphthylamine,  
 15 N,N'-diphenyl-1,4-phenylenediamine, and N-phenyl-N'-cyclohexyl-1,4-phenylenediamine.

Examples of phosphorus antioxidants include phosphite compounds, such as triisodecyl phosphite, triphenyl phosphite,  
 20 trisnonylphenyl phosphite, diphenylisodecyl phosphite, phenyldiisodecyl phosphite,  
 2,2-methylenebis(4,6-di-t-butylphenyl)octyl phosphite, 4,4'-butylidenebis(3-methyl-6-t-butylphenyl)ditridecyl  
 phosphite, tris(2,4-di-t-butylphenyl) phosphite,  
 25 tris(2-t-butyl-4-methylphenyl) phosphite, tris(2,4-di-t-amylphenyl) phosphite, tris(2-t-butylphenyl)  
 phosphite, bis(2-t-butylphenyl)phenyl phosphite, tris[2-(1,1-dimethylpropyl)-phenyl] phosphite,  
 tris[2,4-(1,1-dimethylpropyl)-phenyl] phosphite,  
 30 tris(2-cyclohexylphenyl) phosphite, and tris(2-t-butyl-4-phenylphenyl) phosphite; and phosphine

compounds, such as triethylphosphine, tripropylphosphine, tributylphosphine, tricyclohexylphosphine, diphenylvinylphosphine, allyldiphenylphosphine, triphenylphosphine, methylphenyl-p-anisylphosphine, 5 p-anisyldiphenylphosphine, p-tolyldiphenylphosphine, di-p-anisylphenylphosphine, di-p-tolylphenylphosphine, tri-m-aminophenylphosphine, tri-2,4-dimethylphenylphosphine, tri-2,4,6-trimethylphenylphosphine, tri-o-tolylphosphine, 10 tri-m-tolylphosphine, tri-p-tolylphosphine, tri-o-anisylphosphine, tri-p-anisylphosphine, and 1,4-bis(diphenylphosphino)butane.

Examples of hydroquinone antioxidants include 2,5-di-t-butylhydroquinone; examples of quinoline 15 antioxidants include 6-ethoxy-2,2,4-trimethyl-1,2-dihydroquinoline; and examples of sulfur antioxidants include dilauryl thiodipropionate and distearyl thiodipropionate. Of these, preferred examples of antioxidants include phenolic 20 antioxidants (especially hindered phenols), such as polyol poly[(branched C<sub>3-6</sub> alkyl group and hydroxyl group-substituted phenyl)propionate]. The antioxidants may be used individually or in combination.

25 Examples of the heat stabilizers include nitrogen-containing compounds, e.g., basic nitrogen-containing compounds, such as polyamide, a poly- $\beta$ -alanine copolymer, polyacrylamide, polyurethane, melamine, cyanoguanidine, and melamine-formaldehyde 30 condensation products; and alkali metal- or alkaline earth metal-containing compounds, such as organic carboxylic acid

metal salts (e.g., calcium stearate and calcium 12-hydroxystearate), metal oxides (e.g., magnesium oxide, calcium oxide, and aluminum oxide), metal hydroxides (e.g., magnesium hydroxide, calcium hydroxide, and aluminum hydroxide), and metal carbonates; zeolite; and hydrotalcite. Especially preferred are alkali metal- or alkaline earth metal-containing compounds (especially, alkaline earth metal-containing compounds, such as magnesium compounds and calcium compounds), zeolite, and hydrotalcite. The heat stabilizers may be used individually or in combination.

Examples of the ultraviolet light absorbers include conventionally known benzophenone, benzotriazole, cyanoacrylate, salicylate, and oxalic anilide ultraviolet light absorbers. Examples include a [2-hydroxy-4-(methacryloyloxyethoxy)benzophenone]-methyl methacrylate copolymer, a [2-hydroxy-4-(methacryloyloxymethoxy)benzophenone]-methyl methacrylate copolymer, a [2-hydroxy-4-(methacryloyloxyoctoxy)benzophenone]-methyl methacrylate copolymer, a [2-hydroxy-4-(methacryloyloxydodecyloxy)benzophenone]-methyl methacrylate copolymer, a [2-hydroxy-4-(methacryloyloxybenzyloxy)benzophenone]-methyl methacrylate copolymer, a [2,2'-dihydroxy-4-(methacryloyloxyethoxy)benzophenone]-methyl methacrylate copolymer, a [2,2'-dihydroxy-4-(methacryloyloxymethoxy)benzophenone]-methyl methacrylate copolymer, and a [2,2'-dihydroxy-4-(methacryloyloxyoctoxybenzophenone)]-methyl methacrylate copolymer. The ultraviolet light absorbers

may be used individually or in combination.

Examples of the lubricants include petroleum lubricating oil, such as liquid paraffin; synthetic lubricating oil, such as halogenated hydrocarbon, diester oil, silicone oil, and fluorine silicone; various modified silicone oil (epoxy-modified, amino-modified, alkyl-modified, or polyether-modified); silicone lubricating substances, such as copolymers of an organic compound, such as polyoxy alkylene glycol, and silicone; silicone copolymers; various fluorine surfactants, such as fluoroalkyl compounds; fluorine lubricating substances, such as trifluoromethylene chloride low polymers; waxes, such as paraffin wax and polyethylene wax; higher aliphatic alcohols; higher aliphatic amides; higher fatty esters; higher fatty acid salts; and molybdenum disulfide. Of these, a silicone copolymer (which is obtained by block- or graft-polymerizing a resin with silicone) is especially preferably used. The silicone copolymer may be one which is obtained by block- or graft-polymerizing an acrylic resin, a polystyrene resin, a polynitrile resin, a polyamide resin, a polyolefin resin, an epoxy resin, a polybutyral resin, a melamine resin, a vinyl chloride resin, a polyurethane resin, or a polyvinyl ether resin with silicone, and it is preferred to use a silicone graft copolymer. These lubricants may be used individually or in combination.

Examples of the waxes include olefin waxes, such as a polypropylene wax and a polyethylene wax, paraffin waxes, Fischer-Tropsch wax, microcrystalline wax, montan wax, fatty amide waxes, higher aliphatic alcohol waxes, higher fatty acid waxes, fatty ester waxes, carnauba wax, and rice wax. These

waxes may be used individually or in combination.

Examples of the coloring agents include inorganic pigments, organic pigments, and dyes. Examples of inorganic 5 pigments include chromium pigments, cadmium pigments, iron pigments, cobalt pigments, ultramarine blue, and Prussian blue. Specific examples of organic pigments and dyes include carbon 10 black; phthalocyanine pigments, such as copper phthalocyanine; quinacridone pigments, such as quinacridone magenta and quinacridone red; azo pigments, such as Hansa yellow, disazo yellow, permanent yellow, permanent red, and naphthol red; nigrosine dyes, such as spirit black SB, nigrosine base, and oil black BW; oil blue; and alkali blue. The coloring agents may be used individually or in combination.

15

Examples of the crystallization promoters include organic acid salts, such as sodium p-t-butylbenzoate, sodium montanate, calcium montanate, sodium palmitate, and calcium stearate; inorganic salts, such as calcium carbonate, calcium 20 silicate, magnesium silicate, calcium sulfate, barium sulfate, and talc; and metal oxides, such as zinc oxide, magnesium oxide, and titanium oxide. These crystallization promoters may be used individually or in combination.

25

The composition of the present invention may be subjected to known treatment. For example, for inhibiting the biodegradable polymer compound in the composition of the present invention from hydrolyzing, the composition of the present invention may be irradiated with an active energy ray.

30

Examples of active energy ray sources include

electromagnetic waves, electron beams, particle beams, and combinations thereof. Examples of electromagnetic waves include ultraviolet rays (UV) and X-rays, and examples of particle beams include beams of elementary particles, such 5 as protons or neutrons. Of these, especially preferred is electron beam irradiation using an electron accelerator.

Irradiation of the above active energy rays can be made using a known apparatus. Examples include a UV radiation 10 apparatus and an electron accelerator. With respect to the irradiation dose and the intensity of irradiation, there is no particular limitation as long as the biodegradable polymer compound in the composition of the present invention is effectively inhibited from hydrolyzing. For example, in the 15 electron beam irradiation, the acceleration voltage is preferably about 100 to 5,000 kV, and the irradiation dose is preferably about 1 kGy or more.

The composition of the present invention can be applied 20 to a variety of uses. For example, using the composition of the present invention, a shaped article, e.g., a housing for electrical appliance, such as radio set, microphone, TV set, keyboard, portable music reproducing machine, and personal computer, can be obtained. Further, the shaped article can 25 be used not only in a housing for electrical appliance but also in other applications, such as packaging materials.

Examples of the shaping methods for the shaped article include film blowing, extrusion, and injection molding, and, 30 of these, especially preferred is injection molding. More specifically, the extrusion can be conducted by a general

method using a known extruder, such as a single screw extruder, a multi-screw extruder, or a tandem extruder. The injection molding can be conducted by a general method using a known injection molding machine, such as an in-line screw injection 5 molding machine, a multi-layer injection molding machine, or a twin-cylinder injection molding machine.

Hereinbelow, Examples of the present invention will be described in detail while comparing with Comparative Examples, 10 but the following Examples should not be construed as limiting the scope of the present invention.

#### Examples 1 to 8 and Comparative Example 1

##### 15 (Preparation of specimens)

As the biodegradable resin (A), polylactic acid, Lacea (H100J; manufactured and sold by Mitsui Chemicals, Inc.) was used, and, as the flame retardant additives (B) and hydrolysis inhibitor (C), the corresponding reagents were used. The 20 components A, B, and C were mixed together using a melt-kneading method. The kneading was conducted under conditions such that Minimax-mixtruder (manufactured and sold by Toyo Seiki Seisaku-Sho, Ltd.) was used as a kneader, the nozzle temperature was 170 to 175°C, the torque was 4 to 6 kg, and 25 the residence time was 3 seconds or less. The resultant resin composite was ground and then pressed under 300 kg/cm<sup>2</sup> at 170°C, and shaped into a plate having a thickness of 1.0 mm, followed by cutting out into 12.7 mm × 127 mm, thus obtaining a test specimen.

30

The formulations (compound; parts by weight) of the

specimens prepared for the Examples and Comparative Example are shown below.

Table 1

5

	Biodegradable resin	Flame retardant additive	Hydrolysis inhibitor
Example 1	Polylactic acid; 83	Al(OH) <sub>3</sub> ; 15	Dicyclohexylc arbodiimide; 2
Example 2	Polylactic acid; 68	Al(OH) <sub>3</sub> ; 30	Dicyclohexylc arbodiimide; 2
Example 3	Polylactic acid; 83	Mg(OH) <sub>2</sub> ; 15	Dicyclohexylc arbodiimide; 2
Example 4	Polylactic acid; 68	Mg(OH) <sub>2</sub> ; 30	Dicyclohexylc arbodiimide; 2
Example 5	Polylactic acid; 88	(NH <sub>4</sub> ) <sub>3</sub> (P <sub>n</sub> O <sub>3n+1</sub> ) <sup>(n+2)</sup> ; 10	Dicyclohexylc arbodiimide; 2
Example 6	Polylactic acid; 78	(NH <sub>4</sub> ) <sub>3</sub> (P <sub>n</sub> O <sub>3n+1</sub> ) <sup>(n+2)</sup> ; 20	Dicyclohexylc arbodiimide; 2
Example 7	Polylactic acid; 78	SiO <sub>2</sub> ; 20	Dicyclohexylc arbodiimide; 2
Example 8	Polylactic acid; 78	Low-melting point glass; 20	Dicyclohexylc arbodiimide; 2
Comparative Example 1	Polylactic acid; 100	-	-

In the Table, n represents an integer.

(Burning test)

A burning test was conducted in accordance with UL-94HB using the above-prepared test specimens. The method is described below. Lines across each specimen were drawn respectively at 25.4 mm and 102 mm from one end of the specimen. The specimen was held at the end farther from the 25.4 mm line so that the longitudinal axis of the specimen was horizontal and the transverse axis was at an angle of 45 degrees. A wire gauze was horizontally held below the specimen so that a gap between the bottom of the specimen and the wire gauze became 9.5 mm and the free end of the specimen and the edge of the

wire gauze were on the same line. A burner was placed far from the specimen, and ignited and controlled so as to produce a blue flame having a height of 25 mm. The gas feed and the air inlet of the burner were first adjusted to produce a blue  
5 flame having a height of 25 mm and having a yellow flame at the tip, and then the air feed was increased so that the yellow flame at the tip disappeared. The height of the flame was measured again and adjusted to be 25 mm. The flame was applied to the bottom of the free end of the specimen. In this instance,  
10 the center axis of the burner tube, which was at an angle of about 45 degrees to the horizontal, and the longitudinal axis of the specimen at the lower edge were on the same vertical plane. The flame was applied to the front end of the specimen in a depth of about 6 mm for 30 seconds without moving the  
15 position of the burner, and then the flame was removed from the specimen. When the specimen burned up to the 25.4 mm mark before completion of the flame application for 30 seconds, the flame application was terminated at a point in time when the flame front reached the 25.4 mm mark. When burning  
20 continued on the specimen after removing the flame, a time of burning of the specimen between the 25.4 mm mark and the 102 mm mark was measured to determine a burning rate.

The results of the burning test with respect to each of  
25 the test specimens obtained in the Examples and Comparative Example are shown below.

Table 2

	Burning rate
Example 1	Burning stopped before 102 mm mark.
Example 2	Burning stopped before 102 mm mark.
Example 3	Burning stopped before 102 mm mark.
Example 4	Burning stopped before 102 mm mark.
Example 5	Burning stopped before 102 mm mark.
Example 6	Burning stopped before 102 mm mark.
Example 7	57.4 (mm/min)
Example 8	Burning stopped before 102 mm mark.
Comparative Example 1	81.2 (mm/min)
For reference	76.2 (mm/min)

In the Table above, the value shown at the "For reference" column is the requirement value of UL-94HB.

5

As can be seen from the Table above, the specimens in Examples 1 to 8 individually have succeeded in imparting flame retardancy to the composition having biodegradability, as compared to the specimen in Comparative Example 1. Further, 10 the burning rate of each of the specimens in Examples 1 to 8 satisfactorily meets the standard requirements of UL-94HB.

Examples 9 to 11 and Comparative Example 2

15 The formulations (compound; parts by weight) of the specimens prepared for the Examples and Comparative Example are shown below. Preparations of the specimens were conducted in the same manner as in the above Examples.

Table 3

	Biodegradable resin	Flame retardant additive	Hydrolysis inhibitor
Example 9	Polylactic acid; 93	Talc; 5	Dicyclohexyl carbodiimide; 2
Example 10	Polylactic acid; 83	Talc; 15	Dicyclohexyl carbodiimide; 2
Example 11	Polylactic acid; 68	Talc; 30	Dicyclohexyl carbodiimide; 2
Comparative Example 2	Polylactic acid; 98	-	Dicyclohexyl carbodiimide; 2

(Burning test: horizontal)

5 A horizontal burning test was conducted in accordance with UL-94HB using the above test specimens. The method is described below. Lines across each specimen were drawn respectively at 25.4 mm and 102 mm from one end of the specimen. The specimen was held at the end farther from the 25.4 mm line

10 so that the longitudinal axis of the specimen was horizontal and the transverse axis was at an angle of 45 degrees. A wire gauze was horizontally held below the specimen so that a gap between the bottom of the specimen and the wire gauze became 9.5 mm and the free end of the specimen and the edge of the

15 wire gauze were on the same line. A burner was placed far from the specimen, and ignited and controlled so as to produce a blue flame having a height of 25 mm. The gas feed and the air inlet of the burner were first adjusted to produce a blue flame having a height of 25 mm and having a yellow flame at

20 the tip, and then the air feed was increased so that the yellow flame at the tip disappeared. The height of the flame was measured again and adjusted to be 25 mm. The flame was applied to the bottom of the free end of the specimen. In this instance, the center axis of the burner tube, which was at an angle of

about 45 degrees to the horizontal, and the longitudinal axis of the specimen at the lower edge were on the same vertical plane. The flame was applied to the front end of the specimen in a depth of about 6 mm for 30 seconds without moving the 5 position of the burner, and then the flame was removed from the specimen. When the specimen burned up to the 25.4 mm mark before completion of the flame application for 30 seconds, the flame application was terminated at a point in time when the flame front reached the 25.4 mm mark. When burning 10 continued on the specimen after removing the flame, a time of burning of the specimen between the 25.4 mm mark and the 102 mm mark was measured to determine a burning rate.

A 94HB rated material, namely, a material that is 15 classified into 94HB must meet two standard requirements that (a) burning stop before the 102 mm mark, and that (b) the burning rate be 76.2 mm/minute or less.

(Burning test: vertical)

20 A vertical burning test was conducted in accordance with UL-94V0 to 2 using the above test specimens. The method is described below. Each specimen was held at 6.4 mm from the top by means of a clamp of a ring stand so that the longitudinal axis of the specimen was vertical and the top of a burner and 25 the horizontal layer of dried surgical absorbent cotton were positioned, respectively, 9.5 mm and 305 mm below the bottom of the specimen. In preparation of the horizontal layer, an approximately 12.7 mm x 25.4 mm piece was taken out from mass of cotton using a thumb and a forefinger, and the piece of 30 cotton was thinned and spread by the fingers to form a 50.8 mm square having a natural thickness of 6.4 mm.

A burner was placed far from the specimen, and ignited and controlled so as to produce a blue flame having a height of 19 mm. The gas feed and the air inlet of the burner were 5 first adjusted to produce a blue flame having a height of 19 mm and having a yellow flame at the tip, and then the air feed was controlled so that the yellow flame at the tip disappeared. The height of the flame was measured again and adjusted if necessary.

10

A test flame was applied to the center of the bottom of the test specimen for 10 seconds. Then, the flame was removed at least 152 mm away from the specimen to record a time of flaming combustion. Immediately after the flame on the 15 specimen disappeared, a test flame was applied again to the bottom of the specimen. After another 10 seconds, the flame was removed to record a time of flaming or glowing combustion. When visual inspection is difficult to judge whether flaming or glowing combustion occurs, surgical cotton is brought into 20 contact with the site in question. If the cotton ignites, the combustion is considered flaming. When a melting or flaming material drips from the specimen during the flame application, the burner may be at an angle of 45 degrees during the flame application, and further may be slightly away from 25 any one of the 12.7 mm surfaces of the specimen to prevent the material from dripping into the burner tube. If a melting or flaming material drips from the specimen or continues to burn throughout the test, the burner must be held by a hand to keep a 9.5-mm gap between the bottom of the specimen and 30 the tip of the burner tube during the flame application. All the drips of melting material can be neglected, and a flame

must be applied to the center of a specimen.

A 94V-2 rated material, namely, a material that is classified into 94V-2 must meet the following requirements.

5 (a) Flaming combustion for each specimen does not continue for 30 seconds or more after each flame application.

(b) Total time of flaming combustion after 10 flame applications for a set of 5 specimens is not more than 250 seconds.

10 (c) Flaming or glowing combustion for each specimen does not reach the holding clamp.

(d) Ignition of dried surgical absorbent cotton placed 305 mm below the specimen caused by flaming drips from the specimen is acceptable.

15 (e) Glowing combustion for each specimen does not continue for 60 seconds or more after the second removal of flame.

The results of the burning tests with respect to each of the test specimens obtained in Examples 9 to 11 and 20 Comparative Example 2 are shown below.

Table 4

	Horizontal burning test	Vertical burning test
Example 9	Burning stopped before 102 mm mark.	UL94-V2; $\circ$
Example 10	Burning stopped before 102 mm mark.	UL94-V2; $\circ$
Example 11	Burning stopped before 102 mm mark.	UL94-V2; $\circ$
Comparative Example 2	93.5 mm/min	UL94-V2; $\times$

25 In the Table above, the indication "UL94-V2;  $\circ$ " denotes

that the specimen is a 94V-2 rated material, and the indication "UL94-V2; x" denotes that the specimen is not a 94V-2 rated material.

5        As can be seen from the Table above, the specimens in Examples 9 to 11 individually have succeeded in imparting flame retardancy to the composition having biodegradability, as compared to the specimen in Comparative Example 2. Further, the burning rate of each of the specimens in Examples 9 to  
10      11 satisfactorily meets the standard requirements of UL-94HB, and satisfactorily meets the standard requirements of UL-94V2.

#### Examples 12 to 19 and Comparative Example 3

15       The formulations (compound; parts by weight) of the specimens prepared for the Examples and Comparative Example are shown below. Preparations of the specimens were conducted in the same manner as in the above Examples.

Table 5

	Biodegradable resin	Flame retardant additive	Hydrolysis inhibitor
Example 12	Polylactic acid; 93	Aluminum hydroxide; 5	Dicyclohexyl carbodiimide; 2
Example 13	Polylactic acid; 88	Aluminum hydroxide; 10	Dicyclohexyl carbodiimide; 2
Example 14	Polylactic acid; 78	Aluminum hydroxide; 20	Dicyclohexyl carbodiimide; 2
Example 15	Polylactic acid; 68	Aluminum hydroxide; 30	Dicyclohexyl carbodiimide; 2
Example 16	Polylactic acid; 48	Aluminum hydroxide; 50	Dicyclohexyl carbodiimide; 2
Example 17	Polylactic acid; 93	Magnesium hydroxide; 5	Dicyclohexyl carbodiimide; 2
Example 18	Polylactic acid; 73	Magnesium hydroxide; 25	Dicyclohexyl carbodiimide; 2
Example 19	Polylactic acid; 48	Magnesium hydroxide; 50	Dicyclohexyl carbodiimide; 2
Comparative Example 3	Polylactic acid; 98	-	Dicyclohexyl carbodiimide; 2

With respect to each of the test specimens obtained in  
 5 Examples 12 to 19 and Comparative Example 3, a horizontal  
 burning test and a vertical burning test were individually  
 conducted in the same manner as in the above Examples. The  
 results are shown in the Table below.

Table 6

	Horizontal burning test	Vertical burning test
Example 12	Burning stopped before 102 mm mark.	UL94-V2; $\circ$
Example 13	Burning stopped before 102 mm mark.	UL94-V2; $\circ$
Example 14	Burning stopped before 102 mm mark.	UL94-V2; $\circ$
Example 15	Burning stopped before 102 mm mark.	UL94-V2; $\circ$
Example 16	Burning stopped before 102 mm mark.	UL94-V2; $\circ$
Example 17	Burning stopped before 102 mm mark.	UL94-V2; $\circ$
Example 18	Burning stopped before 102 mm mark.	UL94-V2; $\circ$
Example 19	Burning stopped before 102 mm mark.	UL94-V2; $\circ$
Comparative Example 3	93.5 mm/min	UL94-V2; $\times$

5 In the Table above, the indication "UL94-V2;  $\circ$ " denotes that the specimen is a 94V-2 rated material, and the indication "UL94-V2;  $\times$ " denotes that the specimen is not a 94V-2 rated material.

10 As can be seen from the Table above, the specimens in Examples 12 to 19 individually have succeeded in imparting flame retardancy to the composition having biodegradability, as compared to the specimen in Comparative Example 3. Further, the burning rate of each of the specimens in Examples 12 to 19 satisfactorily meets the standard requirements of UL-94HB, 15 and satisfactorily meets the standard requirements of UL-94V2.

20 By adding to a material comprising a biodegradable polymer compound, such as a biodegradable resin, a flame retardant additive and a hydrolysis inhibitor for the biodegradable polymer compound, a composition having biodegradability and

flame retardancy as well as mechanical strength can be obtained. Specifically, the composition of the present invention is advantageous not only in that it has excellent flame retardancy, but also in that the composition disposed of decomposes into 5 substances harmless to living bodies and the environment, for example, alumina, water, carbon dioxide, and the like, so that the composition does not adversely affect the peripheral environment and human body. In addition, by using the composition of the present invention in housings for electrical 10 appliance or packaging materials, satisfactory consideration of the environment is realized, as compared to the conventional one.